societies will now have greater facilities than ever before.

Those of us who were associated with the club in its infancy are watching with most intense interest its evolution into maturity. We are expecting great things of the Chemists' Club and I am sure we shall not be disappointed. With its past as a background, with its organization and equipment as a foundation, and with the opportunities before it as inspiration, the auguries for the future are bright indeed.

WM. MCMURTRIE

THE WORK OF THE "MICHAEL SARS" IN THE NORTH ATLANTIC IN 1910[1]

DR. HJORT'S preliminary account of the *Michael Sars* expedition is so important, both to the oceanographer and to the marine biologist, that a résumé is justified, although the final report is yet to come.

The expedition, under the direction of Sir John Murray and Dr. Hjort, left Plymouth in April, ran thence to the west of Ireland, across the Bay of Biscay to Gibraltar, and so to the Canaries. From here the course was a "large section of the Atlantic," visiting the Azores, the Sargasso Sea and eventually Newfoundland, whence a section was undertaken to Ireland. Finally work was carried on south and north of the Wyville Thompson ridge.

Especially instructive are the hydrographic sections of the northwestern Atlantic, the observations on currents in the Straits of Gibraltar and off the Azores, the notes on the smaller plankton, and the data acquired on the bathymetric distribution of the fishes and crustaceans of the intermediate waters.

The sections from the Sargasso Sea to Newfoundland and from Newfoundland to Ireland show that the surface layer of warm water with high salinity (over 35 per m.) is very much thicker on the eastern than on the western side of the Atlantic. Off the Newfoundland bank the uniform "bottom water" with a temperature of about 2.5° C., and salinity of about 34.9 per m., rises close to the surface.

If we compare these observations with data obtained by the *Challenger* and by the *Blake*, with the scattered records made by the *Albatross*, and with the few temperatures I have myself taken in the intermediate waters of the Gulf Stream, we find that they are all in accord on this main point. In the northern portion of the Gulf Stream its warm waters are extremely shallow along its inner edge.

The two sections in question illustrate what to the oceanographer is a most important discovery; viz., an upwelling of the cold bottom water partially dividing the warm surface layer into two bands. Thus on the line Newfoundland-Ireland, the temperature at station 83 at about 275 fathoms is the same as it is at 350 fathoms at stations 81 and 85, east and west of it; *i. e.*, 8° C. (46.4° F.). And the salinity curve shows a similar rise. On the line Sargasso Sea-Newfoundland, the "sunderance" of the warm surface water is much more extreme. Thus at station 66 water of 8° C. (46.4° F.) was found at only about 150 fathoms, and of only 14° C. (57.2° F.) and salinity of 35 per m. within less than 50 fathoms of the surface.

On looking over the *Challenger* temperatures on the line Halifax-Bermuda, taking the actual observations, and not those computed from the "average curve" I was struck by the fact that at station 53, at roughly the same relative position, the temperature at 100 and at 300 fathoms was about the same as it was about 50 fathoms deeper at stations 52 and 54, on either side of it. The variation of only about 1° F. is a very slight one, but taken in conjunction with the observations of the *Michael Sars*, and with the fact that the upward swing of the isotherms lies in the direct continuation of the cold ridge shown by Dr. Hjort in his chart of the conditions at 200 fathoms, it certainly suggests the *possibility* that it was an actual phenomenon in 1873 as it was in 1910, not a faulty observation.

Dr. Hjort suggests that if this remarkable

[1] Johan Hjort, "The 'Michael Sars' North Atlantic Deep-sea Expedition, 1910," *Geographical Journal*, Vol. 37, 1911, pp. 349–377, 500–523.

phenomenon proves to be a regular feature, which is, of course, still doubtful, it indicates the existence of a counter current running to the southwest. This may be the correct explanation. But, as he cautions us, it requires further investigation, especially to test its constancy. Vertical circulation, as well as horizontal, may be playing its part here. Current measurements at different depths could not fail to yield valuable results.

As a whole the intermediate waters proved to be considerably colder in 1910 than they were in 1873, differences as great as 5° C. being observed, though the surface and the deeper layers agreed fairly well wherever the paths of the two expeditions approached each other. Such periodic fluctuations are known for the Norwegian Sea, but they offer a virgin and most interesting field in the northwestern Atlantic.

The shallowness of the warm surface layer in the western part of the Atlantic leads Dr. Hjort to conclude that its cold bottom waters come to it from the northwest; *i. e.,* from Baffins Bay. In this connection an examination of the Labrador current would be of great value; as yet we know almost nothing about the physical properties of the intermediate waters north of, and at its meeting with, the Gulf Stream, though its importance as a surface phenomenon has long been recognized.

The character of this Arctic flow, and its relationships to the Gulf Stream and to the comparatively warm water along the western shores of Greenland offer an attractive and important field for oceanographic research, one lying naturally at the doors of American oceanographers. In such a study, current measurements at different depths on and near the Newfoundland banks would be of prime importance. And that such can be made in considerable depths has been proved by the *Michael Sars.*

A series of 70 current measurements were made at eight different depths in the Straits of Gibraltar, from the ship itself, in 200 fathoms. These show very clearly how the inflow into the Mediterranean is limited to the upper 75 fathoms (about) while at its height, with a velocity of about 1 m. per second. On the other hand, when the outflow was at its height the surface current was slight, whereas the current into the Atlantic reached the velocity of 2 m. per second.

A second series of measurements off the Azores show that there may be considerable tidal currents, even as deep as 800 meters.

The biological results are quite as important as the oceanographic. With regard to the finer plankton, the most important results are that there is much more in coastal than in oceanic waters, and that in oceanic waters the maximum of vegetable plankton was at about 50 meters, less at the surface.

By the time 100 meters was reached there was only about one tenth as much as 50. Dr. Hjort tells us that the different groups occupy different bathymetric zones, the Peridiniæ nearest the surface, next the coccoliths, and deeper the diatoms. As to quantity, the living plant cells are estimated at 3,000 to 12,000 per liter of sea water.

The collection of the larger plankton, fishes, crustaceans, etc., was very rich; and the depth data were valuable, thanks to the method of using the serial nets developed by Dr. Hjort. For the details of the apparatus I must refer the reader to Dr. Hjort's account; but, essentially, it consisted in using a series of ten different horizontal nets simultaneously at each station. It seems to me, as it did to Dr. Hjort, that "provided that the catches were large . . . the mere numbers would demonstrate *sufficiently convincingly* at what depth the captures had been made."

The data on the vertical occurrence of fishes and crustaceans have proved to be most valuable—they throw an entirely new light on the whole subject. In the first place they show very clearly that the intermediate fishes and crustaceans are not homogeneous so far as their bathymetric range is concerned, but that species closely allied systematically may differ in their distribution. Thus the fish *Cyclothone microdon* and the prawn, *Acanthephyra multispina,* belong to a deeper zone than their relatives *C. signata* and *A. pur-*

purea. Adults of the former group were most abundant below 500 meters, larvæ (*Acanthephyra*) alone were taken in the upper layers of water. The oldest specimens were from the deepest layers, down 1,500 m., and the depth zones for corresponding sizes were deeper on the southern than on the northern lines. The second group, on the other hand, reaches its maximum higher up, at about 500 m., but here too the older specimens were found deeper on the southern than on the northern lines.

As a rule black and red forms prevail among the larger inhabitants of the intermediate waters. This rule is not absolute, since two species of black fishes were found within 150 m. of the surface. But these two, like *Cyclothone signata,* have highly developed light organs. And it is even more significant that all the captures of them from depths less than 500 m. were made at night; furthermore, as Dr. Hjort points out, there are previous records of black fishes, *e. g., Idiacanthus* and *Astronesthes,* being taken close to the surface at night.

Experiments on the penetration of light, carried on by means of an improved photometer, devised by Dr. Helland-Hansen, showed that there is a close correlation between the lower limits of light of different colors and the vertical occurrence of the black fishes and red prawns. Off the Azores the blue and violet rays were still detected at 500 meters, though the red had been absorbed entirely; at 1,000 meters the ultra-violet rays were still perceptible, but at 1,700 no trace of light was found. That is to say, prawns and black fishes, in the day time, are confined to a zone below the penetration of red light: it is only at night that the fish with large light organs are found higher up in the water. While their upper limit is higher in high than in low latitudes, the same must, on physical grounds, be true of the penetration of light. Furthermore, the theoretical calculations of the penetration of light at different latitudes shows that it agrees very well with the upper limits of the red prawns from the lines of the *Michael Sars* and from the Norwegian Sea.

At a higher level than that occupied by the red and black forms, where sunlight is appreciable, *i. e.,* with a lower limit, in temperate latitudes, of say 500 m.; and a maximum at about 300 m. is a totally distinct fish fauna, characterized by lateral compression, larger and often telescopic eyes, large light organs and silvery sides, examples being afforded by *Argyropelecus* and by various Sternoptychidæ and Stomiatidæ.

These observations rest on such a mass of data that they seem altogether worthy of acceptance. They form one of the most important of recent additions to oceanic biology. They are of special interest to the reviewer because of his studies on the medusæ of the intermediate waters collected by the *Albatross.* Among the latter, as among the fishes, there are two distinct color groups, one slightly pigmented, if at all, but iridescent; the other densely pigmented with red or brown. Both have numerous representatives. Our knowledge of their vertical occurrence is still scanty; but we know that they do not normally come to the surface, except in very high latitudes. On the other hand, they are by no means confined to abyssal depths. The important question in connection with Dr. Hjort's article is whether the two color-groups of medusæ correspond to the two color-groups of fishes in their bathymetric occurrence. To this an answer can not be given definitely as yet. I have already suggested[2] that it is light which demarks their upper limit as a whole. And it is at least suggestive that at one station in the eastern tropical Pacific the *Albatross* took 3 genera of "red" medusæ in a Tanner closing net at 400 fathoms (one of them being also taken in an open net from 300 fathoms), but none of the "iridescent" group, while at the same station two "iridescent" genera were taken in the closing net from 300 fathoms, and two others in the open net from the same depth. These records suggest that at this station, at least, the red medusæ occurred as a whole below the iridescent ones, but that the two overlapped at, say, 300–250 fathoms. One may

[2] *Mem. Mus. Comp. Zool.,* Vol. 37.

hope for much more extensive, perhaps conclusive, evidence along this line when the medusæ of the *Michael Sars* are worked up.

Dr. Hjort believes that the zone marking the upper limit of the red and black forms is particularly rich quantitatively, a view to which I subscribe, having already argued that it is probably true for the medusæ. If his observation that there is a sudden rise in density as we go down through the intermediate layers, where sinking organic débris would tend to accumulate, be extended to the oceans as a whole, it must be one of the most important factors in the ecology of the mesoplankton. In this connection, of course, it is neither salinity nor specific gravity reduced to a standard temperature which is required, but the density of the water at the temperature *in situ*.

Among the mass of surface forms Dr. Hjort mentions especially the transparent fish larvæ, 90 per cent. of which were secured within 150 meters of the surface; of special interest being the occurrence there of pale larvæ of the black *Gonostoma elongatum*, and of deep-sea macrurids. On the other hand, the larvæ of other deep-water forms were taken at about the same bathymetric levels as the adults. In these cases the larvæ are not transparent, but show the pigmentation of the adult. Their color and vertical occurrence are correlated from the earliest stages.

The notes on horizontal distribution are valuable. Thus the captures have extended the ranges of several "rare" deep-water forms to practically the whole north Atlantic; others, however, especially several species of *Cyclothone*, seem to be limited to southern regions. The three centers of abundance for transparent young fish were south of the Azores, west of the Canaries, and off the Newfoundland bank. Among them many interesting stalked-eyed forms were taken, and large series of Leptocephali of at least 20 species.[3]

Finally we have an account of the trawlings. As yet the material is only partially worked up; and as the results may be expected to be of great general interest, it is best to delay our review of them till the final account appears, merely pointing out here the uniformity of the fish fauna at 500 fathoms, from the Wyville Thomson ridge to the Canaries, as opposed to its great diversity in shallow water. The work also supported earlier conclusions that there are some species of fishes and invertebrates south of the ridge separating the Atlantic from the Norwegian Sea, not found north of it, and *vice versa*.

In conclusion, every student of oceanic phenomena owes a debt of gratitude to Dr. Hjort and to Sir John Murray for the well-planned and successfully executed operations of the expedition. The methods employed deserve to be, and will be generally, adopted. To those of us who have participated in deep-sea investigation, it is a revelation that so much and such good work could be done from a vessel of only 226 tons, and that financial obstacle need no longer loom so large as it has in the past.

As Dr. Hjort points out, the Atlantic is still a "fruitful field for future investigation into the pelagic life of the ocean"; and he has himself opened many attractive vistas to other students.

Henry B. Bigelow

[3] Some of these, the larvæ of the European eel, have been described in an earlier paper (*Nature*, November 24, 1910).

SCIENTIFIC NOTES AND NEWS

Dr. Abraham Jacobi, emeritus professor in Columbia University, was elected president of the American Medical Association, at the meeting held last week at Los Angeles.

Professor William G. Raymond, head of the department of civil engineering and dean of the College of Applied Science at the State University of Iowa, has been elected president of the Society for the Promotion of Engineering Education.

Harvard University has conferred the doctorate of letters on Dr. Josiah Royce, professor of philosophy, and the degree of master of arts on Dr. William B. Coley, professor of clinical surgery in Cornell Medical College,